Chapter 4.1 NONPOINT SOURCE ASSESSMENT, PRIORITIZATION, AND ACTIVITIES

This section of the Virginia Water Quality Assessment 305(b) Report includes an assessment of nonpoint source (NPS) pollution potential at the smallest statewide hydrologic unit level[1] currently in use (hereafter referred to as either hydrologic units or just units). It also includes indicators for prioritizing NPS corrective actions at the hydrologic unit level and a summary of NPS reduction activities currently underway. It has been prepared by the Virginia Department of Conservation and Recreation (DCR) to provide a comparative evaluation of the state's waters, on a hydrologic unit basis (see Table 4.1-3) for assisting in the targeting of limited resources and funds for NPS pollution protection activities to where they are most needed.

The 2006 NPS Assessment and Prioritization study summarizes information from DCR, the Virginia Department of Environmental Quality (VDEQ), Virginia Department of Forestry (VDOF), U.S. Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS), local Soil and Water Conservation Districts (SWCDs), the Department of Biological Systems Engineering (BSE) of the Virginia Polytechnic Institute and State University (VPI&SU), the Virginia Department of Health (VDH), the Virginia Department of Game and Inland Fisheries (VDGIF), the Virginia Department of Mines, Minerals, and Energy (VDMME), the Center for Environmental Studies (CES) at Virginia Commonwealth University (VCU), the US Environmental Protection Agency (EPA), the Chesapeake Bay Program (CBP), and other existing sources of information concerning nonpoint source impacts to Virginia waters.

There are three major components to the 2006 NPS Assessment and Prioritization study - potential pollutant loadings, water quality impairments, and measures of biological health. The main focus is the determination of potential loadings of nitrogen, phosphorus, and sediment (hereafter referred to as NPS pollutants) by hydrologic unit by general land use categories. The evaluation of hydrologic units by impaired waters and aquatic species health represents water quality measures not necessarily related to NPS pollutant loads. In order to prioritize clean-up and protection activities, hydrologic units of prime importance for the protection of public surface water supplies were also determined. Details on these components follow.

NPS POLLUTION LOADINGS

The NPS Assessment of pollutant loadings is a calculation of the estimated edge of stream (EOS) loadings of nitrogen, phosphorus, and sediment per hydrologic unit using a model whose input data sets had spatial resolutions that were much smaller than the hydrologic units themselves.

The calculation of loads of NPS pollutants as a basis for assessing water quality by hydrologic unit is consistent with Virginia's participation as a partner with the EPA's CBP in the calculations of NPS pollutant loads using the Chesapeake Bay Watershed Model (CBWM). Although Virginia uses CBWM results (particularly in CBP related activities), they have only been obtainable for that portion of Virginia within the Chesapeake Bay Watershed (James, York, Rappahannock, Potomac, and Bay Coastal basins). There are other state program needs that can benefit from having measures similar to the CBWM loads but for the non-Bay portion of the state.

In order to obtain statewide NPS pollution values, DCR contracted with the CBP and the US Geological Survey (USGS) to add all of Virginia into the CBWM for Phase 5 of that model. This process is underway but has not yet produced NPS pollutant loads at the Phase 5 model segment level. Therefore, DCR contracted with the VPI&SU BSE Department in 2002 to produce statewide NPS pollutant load results similar to those of the CBWM but using a more simplified model. The BSE chose the Generalized Watershed Loading Functions (GWLF) model[2] for this application. Assistance with GWLF model use, with CBWM use, and with the data requirements for GWLF was provided by the Environmental Resources Research Institute at Penn State University, the CBP, and DCR respectively.

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[1] These units are technically referred to as Virginia's sixth order (14 digit) hydrologic units. The Hydrologic Unit Geography page at www.dcr.virginia.gov/sw/hu.htm contains information about these units.

[2] GWLF was chosen because it was configured for continuous simulation and could produce EOS loads based on land-based loadings, fate, and the transport of pollutants as does the CBWM. Both models also simulate seasonal variations, include both surface and subsurface components, and can represent both dissolved and particulate forms of pollutants.

Before the GWLF model was used to develop NPS pollutant loadings in 2002 for all hydrologic units in Virginia, it was calibrated to replicate CBWM results in the Chesapeake Bay drainage area. For calibration purposes BSE aggregated CBWM model segments into larger calibration regions (10). Regional development was modified during the calibration process, until the regions and their regional adjustment factors in the GWLF model sufficiently produced model output (load results) similar to that produced by the CBWM[3] for the Chesapeake Bay drainage area of Virginia. Non-Bay portions of the state were then related to one of these calibration regions and assigned the relevant factors.

The 2002 assessment runs of GWLF followed the completion of the calibration process. Whereas the CBWM uses and produces data in CBWM-specific model segments (36 in Virginia), the assessment runs of GWLF used and produced data at the hydrologic unit level (493 in Virginia; the Chesapeake Bay itself was not modeled). Assessment runs of GWLF in 2002 differed from the calibration runs in that they used a new 2000 land use / land cover data set developed by DCR and took into consideration the best management practice (BMP) installations and nutrient management planning occurring in Virginia over the previous five year period.

The 2006 assessment runs differ from the assessment runs of 2002 in that the land use / land cover was updated to 2002. It was developed by DCR from a number of sources[4]. The 2006 assessment also took into consideration model-relevant BMP installations and nutrient management planning occurring in Virginia over the immediate five year period (1997-2002) by DCR, the NRCS, VDOF, VDMME, and private plan writers. Table 4.1-1 lists the land use classification system used in the assessment runs of the GWLF model and the equivalent generalized model output land use categories. Spatially attributed BMP and nutrient management plan effects are measured as both land use changes to the aforementioned 2002 land use / land cover data set and as fractional reductions to the loadings by land use. Output from the assessment runs of GWLF is in the form of loads (L) of each NPS pollutant per modeled land use per unit. Loading rates (R) of NPS pollutants (p: nitrogen, phosphorus, and sediment) per hectare (h) of output class land use (l: agriculture, urban, and forest) per hydrologic unit (w) are also reported.

For the purposes of ranking hydrologic units by NPS pollutant loads per land use, the loads per land use per pollutant were distributed to each modeled hectare[5] of a unit to produce a unit area load (UAL) per land use per pollutant for each watershed as follows:

$$UAL(plw) = L(plw) / h(w)$$

The output loadings provided a statewide equivalent of the types of results that Virginia has been able to obtain from the CBWM for the Chesapeake Bay drainage area of the Commonwealth over the last 17 years. Table 4.1-2 compares the final statewide loadings by pollutant by general land use class and the amount of land in Virginia by general land use class. Loading values in this table reflect the loads after the reductions are applied from BMP installations over the previous five years.

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[3] Calibration of the model to match output from version 4.3 of the CBWM required almost 200 runs of GWLF and included revisions to the model.

[4] The base imagery for the 2002 land use / land cover data set was developed by the Mid-Atlantic Regional Earth Science Applications Center (RESAC). It was developed for use in Phase 5 of the CBWM but was extended to all of Virginia with a grant from DCR. Agricultural uses were modified using the USDA 2002 Census of Agriculture and the National Crop Residue Management Survey from the Conservation Technology Information Center (CTIC). Barren classes were modified using data from the VDMME and VDOF. Additional classes were based on processes developed for DCR by The Academy of Natural Sciences of Philadelphia (1997) using data from DCR's confined animal databases.

[5] Not all land uses were modeled (see Table 4.1-1). The area of a particular unit as used in this calculation would not include the hectares of non-modeled land uses occurring in that unit.

Table 4.1-1 Land Use Classification

Original Class	Derived Class	Modeled Class	General Output Class
Conifer Forest Deciduous Forest Mixed Forest Deciduous Wooded Wetlands Conifer Wooded Wetlands Mixed Wetlands (portion)		Forest	Forest
Barren (portion) * Extractive (portion) *	Disturbed Forest	Disturbed Forest	
Row Crop	Conventional Tillage Conservation Tillage	Conventional Tillage Conservation Tillage	Agriculture
Hay/Pasture Natural Grass	Pasture Cattle-Grazed ** Pasture Poultry Litter ** Manure Acres	Hay Pasture Pasture Cattle-Grazed Pasture Poultry Litter Manure Acres	
High Density Residential Medium Density Residential Low Density Residential Urban Residential Grasses Urban Residential Conifer Trees Urban Residential Deciduous Trees Urban Residential Mixed Trees Transportation Barren (portion) * Extractive (portion) *		Impervious Urban & Pervious Urban	Urban
Emergent Wetlands Mixed Wetlands (portion) Open Water Barren (portion) *		not modeled (no loadings)	

* The Extractive and Barren categories from the imagery were combined and apportioned out as Extraction, Disturbed Forest, and true Barren. This apportioning was done to intersected units of hydrologic units and jurisdictions based on where VDMME indicated extraction was occurring and where VDOF indicated forest-harvesting activities were occurring. Disturbed Forest was modeled whereas the apportioned Extraction was modeled as Pervious Urban and true Barren land was assigned no loads.

** Unlike the 2002 NPS Assessment (also used in 2004), Pasture Cattle Grazed and Pasture Poultry Litter are not mutually exclusive. Except for the Eastern Shore of Virginia, all Pasture Poultry Litter is also cattle grazed. Pasture Cattle Grazed is grazed pasture using other forms of fertilizer (typically commercial).

Table 4.1-2 Statewide NPS Pollutant Loads – Post BMP Reduction

	Agricultural Class	Urban Class	Forestry Class
Total VA Land Area *	6,321,961	1,917,121	16,588,940
%of VA Land *	25	7.6	65.7
Total Nitrogen **	43.7	7	7.5
%of all NPS N	75	12	13
Total Phosphorous **	7	0.6	2.4
% of all NPS P	70.5	6	23.5
Total Sediment **	3,398.7	99.9	1,565.9
% of all NPS S	67	2	31

* does not include non-modeled uses (see Table 4.1-1)
** in millions of Kg/year

In order to maintain a consistency with other circulating NPS assessment reports and maps and with the manner in which this data is used, the ranking of hydrologic units for the NPS pollutant UAL components for the 2006 NPS Assessment study has maintained the same division of UALs into categories that has been used before - the top 20% of the values for each component being classified as high, the next 30% being classified as medium, and the remaining 50% classified as low. This ranking methodology applies to the NPS pollutant loads only. These range definitions are not absolute, since units with equal loading values would not be divided into different classes.

Information regarding the NPS pollutant loadings by general land use and as summations per pollutant is found within the following sections.

Agricultural NPS Pollution Loads

Agriculture is a large and diverse industry in Virginia and accounts for approximately 25% of Virginia's land use. While this percentage is significantly lower than the national average and is declining in Virginia, agricultural activities continue to be the most significant source of nonpoint source pollution in the state. As shown in Table 4.1-2, the current assessment model results suggest that despite accounting for about 25% of the land in Virginia agricultural land contributes from 67% to 75% of the NPS pollutant loads.

Nonpoint source contamination from agriculture originates from several different sources with different associated impacts. Deposition of potential NPS pollutants to agricultural lands in the form of fertilizers and animal manures affect water quality when they reach groundwater reserves, are directly deposited to streams, or are washed into streams, lakes, etc during rain storms in either a dissolved state or with eroding soils. These pollutants include pathogens as well as nutrients.

This assessment measured the nutrient and sediment loads from agricultural areas but not the loading of pathogens. Factors in this assessment which affect the amount of nutrient loads reaching water from agricultural lands include the erodability of the soils, types of agricultural practices, types and numbers of farm animals, land cover, stream density, rainfall, seasonal variations in plant growth and nutrient applications, existence and type of agricultural BMPs, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from agricultural land uses are displayed in Figures 4.1-1, 4.1-2, and 4.1-3 respectively. The rankings are also listed in Table 4.1-4.

A number of factors are responsible for the changes in loadings and thus rankings, of the agricultural

NPS pollutants between the 2002 modeling process and the current 2006 product. A more current land use / land cover layer, a more recent (2002) Census of Agriculture (which was used to adjust the land use / land cover layer), an updated database on confined animals, and the latest BMP installations all contributed in capturing some of the trends in Virginia agriculture that affect NPS nutrient loads from agricultural activity. These trends include some changes in dominant crops, an increase in farm animals, and a wider area of crop and pasture to which poultry litter is applied both as a fertilizer and as a means of disposal.

Urban NPS Pollution Loads

Although less than 8% of the land in Virginia is considered urban, urbanization of forest and agricultural land is occurring at a rapid rate in many parts of the Commonwealth. This urbanized growth results in NPS pollution as the result of precipitation washing nutrients, sediment, and other toxic substances from the impervious surfaces that make up these areas. The sources of these surface contaminants include: air and rain deposition of atmospheric pollution; littered and dirty streets; traffic by-products such as petroleum residues, exhaust products, heavy metals and tar residuals from the roads; chemicals applied for fertilization, control of ice, rodents and other pests; and sediment from construction sites. Illegal industrial, commercial and domestic hook-ups to storm sewers also contribute a number of specific pollutants to waterways, as do inadequate sewage disposal systems both for municipalities and individual homes.

This assessment measured only the nutrient and sediment loads from urban areas as opposed to all urban NPS pollutants as described. As calibrated in this model, urban lands include those associated with resource extraction (mining). Factors in this assessment that affect the amount of loads reaching water from urban lands include the degree of imperviousness of the urban land use, impervious area NPS pollutant build-up rates, stream density, rainfall, septic system use, direct discharges, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from urban land uses (as described in Table 4.1-1) are displayed in Figures 4.1-4, 4.1-5, and 4.1-6, respectively. The rankings are also listed in Table 4.1-4. The highlighted units are reflective of the areas of Virginia that are undergoing the most significant urban development activity, as well as those with significant amounts of marginal septic system use. The new base land use / land cover layer and improved tracking of extraction activities (associated with urban uses in the model) by the VDMME are the primary factors in urban load and unit ranking changes between 2002 and 2006.

Urban load measures are based on pollution potential and do not compensate for urban runoff control measures that may be in place in some areas. Such reduction measures are primarily installed by the private sector.

Forestry NPS Pollution Loads

About 66% of the land area of Virginia is forested. Forestland in general produces lower NPS pollutant loads[6] than other land uses. Certain forest disturbing activities such as tree harvesting, site preparation and reforesting however do make a load contribution. As Table 4.1-2 shows, these activities in particular contribute to a large sediment load and subsequent increase in sediment-attached phosphorus.

The classification of land cover imagery can capture bare land and regrowth areas from the aforementioned forest activities. It captures forestland being cleared due to other land disturbing activities as well, such as surface mining and residential development. Due to the similar spectral signatures of these land activities as well as those of non-temporary land covers such as bare rock and beaches, it can be difficult to discern these activities and covers from one another without other associated data.

For this study the DCR staff endeavored to isolate forest disturbing activities found in the imagery from other barren-classified land so as to associate these (perhaps temporarily) barren lands with the most appropriate land use being used in the GWLF model runs. The VDOF, who has been tracking such activities of the forest industry to facilitate the proper management of Virginia's forest resources relative to water quality,

[6] Airborne nutrient pollution is accounted for as part of the load of the land use it falls upon. The majority of the airborne nutrient load falls on forestland in Virginia and is therefore associated more with forestland than with other uses.

supplied data useful for this purpose. In a similar fashion, data from the VDMME on the amounts of resource extraction by county helped isolate true extraction activities from reforesting sites. Whereas disturbed forestland is a component to the nutrient loads from forests, mine lands add to urban loads in this study.

Whereas agricultural activities operate on a yearly or seasonal cycle on agricultural lands, a single cycle of forest harvesting, site preparation, and reforestation occurs over many years. Where the next cycle begins amongst existing forested lands is undetectable from previous land cover images, making the measure of forest disturbance for these activities more of a snapshot than a trend.

Factors in this assessment which affect the amount of loads reaching water from forestlands include the erodability of the soils, existence of disturbed forestlands, stream density, rainfall, existence of forest (silviculture) BMPs, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from forestland uses are displayed in Figures 4.1-7, 4.1-8, and 4.1-9 respectively. The rankings are also listed in Table 4.1-4.

There are a number of factors responsible for the changes in loadings, and thus rankings, of the forest NPS pollutant loads between the 2002 modeling process and the current 2006 product. This includes the aforementioned new land use/land cover layer. More important from a total loadings perspective is the removal of non-forested wetlands from forested wetlands in the modeled land use / land cover data (see Table 4.1-1) and the improved disturbed forest determinations mentioned above. Data from the VDOF show a trend towards increased forest harvesting activities in the southwestern portion of the Commonwealth relative to the eastern portion since 2002.

Total Loads Per NPS Pollutant

Calculated total nitrogen, total phosphorus, and total sediment unit area loads from all land uses combined are displayed in Figures 4.1-10, 4.1-11, and 4.1-12, respectively, and listed in Table 4.1-4. Total nitrogen is composed of septic nitrogen, groundwater nitrogen, dissolved nitrogen from various land uses, wash off of nitrogen from impervious surfaces, and sediment-attached nitrogen. Total phosphorus is composed of septic phosphorus, groundwater phosphorus, dissolved phosphorus from various land uses, wash off of phosphorous from impervious surfaces, and sediment-attached phosphorus. Total sediment is the sediment yield from all land uses.

The summing of NPS pollutant loads by land use into total NPS pollutant loads in this NPS assessment is simply the addition of values with equivalent units (kg/ha/yr of nitrogen or phosphorus, Mg/ha/yr of sediment). Accordingly, the relative weight of the estimated NPS pollutants coming from one land use versus another is directly comparable. This comparison shows that NPS pollutants from agricultural lands dominate the total NPS pollutant loads.

IMPAIRED WATERS

In accordance with US EPA guidance and protocol, the DEQ assembled a list of the water quality -limited riverine, lacustrine, and estuarine waters of Virginia in 2004 (303(d) report). That list of water quality- limited waters is the basis for the impaired waters portion of the 2006 NPS Assessment study.

Waters listed in the 303(d) do not meet one or more of the designated uses for water. Among the many defined attributes in the impaired waters database is the name of the impaired waters, the beginning and ending limits of the impaired portions, impairment causes, and impairment sources. Using this database information, a graphic depiction (layer) of the impaired waters was developed. Only waters listed by the DEQ staff as having NPS related sources or those waters not explicitly listed as having an NPS source but which (a) did not explicitly list any other sources, and either (b) listed possible agriculture related impairment causes[7] or (c) correlated with DCR's areas of nonpoint sources, were considered in this analysis.

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[7] This included all fecal causes of unknown sources since approximately 90% of non-urban fecal problems are surmised to be due to agricultural or natural animal loadings. Similarly, because about 85% of benthic impairments are believed to be sediment related, and because DEQ personnel are more likely to know and document point sources of benthic impairments, all benthic impairments of unknown sources are considered to be NPS related. Impairments with nutrient sources were also included.

Waters in the impaired waters layer that are suspected of being impaired due to nonpoint sources were divided by the hydrologic unit boundaries into segments by unit to allow for the summation of impaired water lengths or areas by these units. The same process performed on all waters in the state determined the total available miles of riverine, acres of lacustrine, and square miles of estuarine waters per hydrologic unit that occur for comparison against the impaired portions.

Whereas the NPS pollutant loads of the 2006 NPS Assessment are measures of nutrients and sediment, most of the NPS impaired waters from the 2004 303(d) report are listed due to the existence of pathogens. Total Maximum Daily Load (TMDL) studies have shown that pet wastes can have a role in high pathogen counts in some urban streams. Concentrations of wildlife can have a similar effect in various land use / land cover settings. Likewise human wastes arising from the existence of straight pipe disposal, failing septic systems, or malfunctioning water treatment plants can all contribute to the impairment of waters due to high levels of pathogens. A significant portion of the waters impaired due to the existence of pathogens however are believed to be impaired because of farm animal wastes.

The number of farm animals by type and by unit is part of the nutrient load calculation, since most farm animal wastes are recycled back to the ground by the animals or in a more controlled mode by farmers who want to fertilize fields and/or remove wastes from confined animal sites. The controlled dispersal of wastes is a goal of Nutrient Management planning and a practice that DCR cost-shares with farmers to implement. The fencing off of stream banks and construction of alternative water sources are two such practices, in this case designed to keep cattle out of and away from streams so as to avoid the sediment loading from eroded stream banks and also avoid the high pathogen counts of direct deposition of manure.

The rankings of hydrologic units by water regime that follows considers all and only NPS-associated impairments.

Riverine Impairments

Summed lengths of NPS impaired riverine water features in 2004 as miles per hydrologic unit were compared to the total miles of riverine systems available per unit to determine the percentage of the available riverine water miles per unit that were NPS impaired. For ranking purposes the highest 10 percent of those percentages were assigned the highest NPS rank for riverine impairments. The next 20 percent were assigned the medium rank, and the others were assigned the lowest rank. The rankings of hydrologic units for impaired riverine waters are displayed in Figure 4.1-13 and listed in Table 4.1-4.

Estuarine Impairments

Since most of the impaired main stem estuarine water bodies in Virginia have listed impairment causes that are not considered to be due to (with any significance) practices occurring in the immediate units that the main-stems flow through, the estuarine waters were divided into the categories "main-stem" and "non main-stem". Main-stem impairment sources are considered to be more broadly dispersed in the basin, including the upstream portions of the basin that are beyond the estuarine system. To prevent the implication that the hydrologic units through which these main-stem estuarine waters flow are responsible for the large amount of impaired estuarine waters in their domain, and erroneously ranking them accordingly, main-stem estuarine waters were not included in the summing of impaired or available estuarine waters per unit. Summed areas of non main-stem impaired estuarine waters in 2004 as square miles per hydrologic unit were compared to the total square miles of non main-stem estuarine waters available per unit to determine the percentage of non main-stem estuarine waters in a unit that were impaired.

Most of the 494 watersheds in Virginia do not contain estuarine waters. With the further disqualification of those that contain only main-stem estuarine waters, only 66 watersheds were included in the ranking of impaired estuarine waters.

Of the hydrologic units included in the impaired estuarine waters ranking process, about 60% contained some impaired non main-stem estuarine waters. Units with more than 35% impaired non main-stem waters were ranked high and the other units were ranked medium. Watersheds with no impaired non main-stem estuarine waters were assigned the lowest rank. The rankings of hydrologic units for impaired non main-stem estuarine waters are displayed in Figure 4.1-14 and listed in Table 4.1-4.

Lacustrine Impairments

It was particularly necessary to divide impaired lake waters by hydrologic unit because some of the larger reservoirs in the state were impaired or contained impaired portions, and these large bodies of water spanned multiple hydrologic units. Summed areas of impaired lacustrine waters in 2004 as acres per hydrologic unit were compared to the total acres of lacustrine waters available per unit to determine the percentage of lake waters in a unit that were impaired.

The vast majority of the hydrologic units in Virginia contained no impaired lake or reservoir waters in 2004 and so they were ranked low. Of those that did, a few had very minor percentages and were therefore also ranked low. Conversely, a few had significant impaired portions (>50%) and were therefore ranked high. All others were ranked medium. The rankings of hydrologic units for impaired lacustrine waters are displayed in Figure 4.1-15 and listed in Table 4.1-4.

BIOLOGICAL HEALTH

Also included in the 2006 NPS Assessment and Prioritization study is information from VDH on public surface water sources and their protection zones, and an evaluation of the health of aquatic species in the state's waters by the CES at VCU. These components provide an additional means to prioritize water quality protection - the protection of the sources of public drinking water and of natural aquatic communities respectively.

Public Source Water Protection

As part of their Source Water Area Protection (SWAP) Program, the VDH determined the area upstream of public surface water intakes that must be investigated for threats to water quality. The most immediate area of their concern is referred to as the Zone 1 for each intake. Zone 1 areas extend out to a 5 mile radius upstream from a water supply intake or 5 miles around a lake containing an intake, without crossing watershed boundaries except those upstream. The population served by an intake, provided by VDH, and the portion of a hydrologic unit that is within a Zone 1 area has been used by DCR to calculate the concentration of persons served per unit by these public surface water supplies. The concentration values serve as a measure of the importance of high water quality by hydrologic unit for public drinking water supply protection.

Concentration values are the summation by hydrologic unit of all Zone 1 areas or combinations of Zone 1 areas in that unit times one one-thousandth of the effective population each serves. In cases where a municipality owned several intakes, the single recording of population served was divided amongst each intake to create an effective population served. In cases of overlapping intake reaches the effective population of each reach was summed for the portion of overlap.

The categorized values and rankings for indicating concentration by unit are displayed in Figure 4.1-16 and listed in Table 4.1-4. As with all the NPS loading variables in this assessment, units that are ranked high are mapped red and represent units of concern – in this case units with a heavy concentration of land immediately upstream from surface water intakes that are used extensively for public drinking use.

Many hydrologic units contained no Zone 1 protection zones or portions of Zone 1 protection zones. The vast majority of those with some Zone 1 content had low levels (< .9) of the calculated measure for concentrations of people served within a watershed. Of the remaining units, a few had significantly higher value measures (> 70) and were therefore classified as "Very High". The rest were divided amongst a moderate category (.9-10) and a high category (10-70).

Aquatic Species Measures

The presence or absence of certain aquatic species can serve as an indication of the overall quality of a particular waterway. They can also indicate where the most biological damage can occur from water quality degradation. Accordingly, the NPS Assessment and Prioritization study provides a ranking of hydrologic units for stream-dependent living resources (including fish, mollusks, and crayfish) using a multi-metric index calculated by the CES at VCU as part of their Interactive Stream Assessment Resource (INSTAR). More information about INSTAR can be found in the INSTAR Chapter of this report.

These indexes (referred to as the miniMIBI - a minimized version of the Modified Index of Biological Integrity) were calculated by the CES using databases[8] originally developed by DCR, the VDGIF, and VCU. By associating a hydrologic unit code to each of the stream segments for which aquatic species information was available in the various databases, metric scores by unit were developed for each of 6 metrics. These metrics are as follows:

Metric 1 – Number of Intolerant Species: refers to the total number of unique water quality intolerant species found in a unit.
Metric 2 - Native Species Richness: refers to the number of indigenous (local) species present in a unit.
Metric 3 - Number of Rare, Threatened and Endangered Species: refers to the number of species that are considered rare, threatened or endangered due to their low population levels that are present in a unit.
Metric 4 - Number of Non-indigenous Species: refers to the number of non-native species present in a unit. These are introduced species that would not normally be found in this particular location.

Metric 5 - Number of Critical Species: refers to the number of species found in a unit that are considered critical because of some important role that they play, such as being a food source or major recreational fishery.
Metric 6 - Number of Tolerant Species: refers to the number of species found in a unit that are tolerant to degraded stream conditions and can survive even in these sub-optimal conditions.

A score for each metric per hydrologic unit was assigned by the CES. In general a high metric score is related to a high rank. A score of zero was given if insufficient data was available. Metrics 4 and 6 were reversed in the scoring, so that a low value for either of these metrics would receive a high metric score. Lower values are more desirable in metrics 4 and 6 because a high number of non-native species and/or a high number of species that are tolerant to stream degradation are less desirable characteristics for a stream. The scores for each metric for each unit were totaled to give an overall total miniMIBI score per hydrologic unit. A category value of High (score of 5), Medium (score of 3), or Low (score of 1) was assigned on a per basin basis based on the total miniMIBI score. Summed scores per hydrologic unit were thusly tiered relative only to the summed scores of the other units in the same basin. The total miniMIBI scores are used to place each hydrologic unit into ranked categories reflecting biotic integrity and resource importance.

Figure 4.1-17 displays, and Table 4.1-4 lists, the categorization of the miniMIBI scores by hydrologic unit. In this figure and table, high miniMIBI scores equate to low ranks, and vice versa. As with all previous variables in this assessment, high ranked units are mapped red and represent units of concern – in this case indications of low water quality based on aquatic species measures.

Since there were 6 metrics and a maximum score of 5 could be obtained for each metric, the overall maximum score a unit could receive was 30 (6 x 5). A majority (112) of the total miniMIBI scores were 16. The 273 hydrologic units with total miniMIBI scores below this average may represent waters with some degree of degradation, but they may also reflect waters where insufficient studies and inventories have occurred. This latter condition is particularly true for coastal watersheds, and is being addressed in further cooperative efforts by the CES, VDGIF, and DCR.

While the maintenance or enhancement of water quality for the protection of all native aquatic life is the preferred goal, these aquatic species priorities should help direct NPS pollution mitigation efforts and other water quality improvement projects toward hydrologic units with the most important aquatic resources.

[8] The DCR database contained information for approximately 600 fish records, representing over 50 species, and over 1,300 mollusk records, representing almost 50 species. The VDGIF database contained information for over 135,000 fish records, representing over 220 unique species, and close to 7,000 mollusk records. With the addition of data from VCU, over 150,000 records were used in this product.

COLLECTIVE USE OF RANKINGS

The 12 rankings assigned to hydrologic units for NPS pollutants by land use, the 3 rankings of units for impaired waters, and the 2 rankings of units for biological health can be used in various combinations to evaluate statewide conditions and prioritize NPS reduction activities. Which measures are included in each prioritization process, and how one weighs in comparison to another, is dependant on the activity to be prioritized. For instance, DCR uses the agricultural NPS pollution rankings as variables in the targeting of agricultural best management practices (see Agricultural Cost Share Program below) and rankings of NPS pollutant loads and biological health were part of the TMDL implementation prioritization (see Total Maximum Daily Loads below).

There are a number of considerations to keep in mind when constructing prioritization processes from these rankings. Perhaps the most important is that some factors are measures potentially being produced at the hydrologic unit of interest, such as the NPS pollutant loadings. Other measures reflect existing conditions at the unit of interest, such as the impaired waters and aquatic species health, and may in part be due to activities occurring in upstream units. The source water concentration values directly account for the upstream affect by virtue of their being based on a designated upstream zone.

Another consideration is the possible incorrect inference of cause and effect. Waters in a unit may be impaired due to nonpoint sources, and subsequently ranked high, but the cause of these waters being listed as impaired is usually not related to the nitrogen, phosphorus, and sediment that is potentially being loaded to these waters in either the unit of concern or upstream of it. Likewise point source loadings can be the reason for the streams in a unit to collectively produce a low miniMIBI score / high aquatic species rank.

The use of the aquatic species unit rankings in any prioritization process can be two-fold. High rank units, having low metric measures, indicate areas of concern that may or may not be reflected in the water quality measures that lead to an impaired waters designation and subsequent ranking of units for impaired waters. These are areas with measurable problems that need to be addressed. On the other hand, low ranked aquatic species units represent areas of high biotic integrity that are deserving of protection, particularly if they contain rare, threatened, and/or endangered species (metric 3). In this view of the data, NPS pollutant loadings in these units and those in nearby upstream units would be a significant targeting measure for NPS reduction activities.

NPS REDUCTION ACTIVITIES

Efforts to reduce NPS pollution in Virginia have been undertaken by a full range of government agencies - federal, state, regional, and local, as well as by citizen action. In many cases the activities are cooperatively performed and funded. The Annual 2004 Virginia Nonpoint Source Pollution Program Report, found at www.dcr.virginia.gov/sw/ss319.htm, contains descriptions of the cooperative NPS reduction activities. Most of these efforts target particular watersheds. Among them, and elaborated on here, are the TMDL studies and implementation, Tributary Strategies, Agricultural Cost Share incentive programs for BMP installations, and incentives for the set aside of agricultural land.

Total Maximum Daily Loads

TMDLs, described elsewhere in this 305(b) report, are performed for waters that have been determined to be impaired and are so listed in the State's 303(d) report. Waters are not listed as impaired however due to high concentrations of nitrogen, phosphorus, or sediment, but rather because they cannot support, or can only partially support, one or more of the designated uses. This is because water quality standards do not exist for concentrations of these NPS pollutants. Nevertheless, certain impairment causes are primarily due to nonpoint source pollutants (see Impaired Waters in this chapter) and DEQ staff has often determined that there are nonpoint sources for these impairments.

Using the logic of the impaired waters rankings of the NPS Assessment study, all impairments for which one or more of the stages of a TMDL have begun were divided between those with and those without a nonpoint source. Most of the waters declared impaired in Virginia are or are believed to be, impaired due to, or partially due to, nonpoint source pollution. Consequently, most of the TMDLs that are being undertaken have a nonpoint source component. These studies are focusing on identifying the sources of the impairment causes, quantifying the loadings of these sources to the water, and determining the reduction in loads needed in order to meet the use criteria. The development of an implementation plan is expected following the completion of a TMDL study for a particular watershed. Implementation of the plan's course of action then follows.

Including the 2006 cycle there are now 47 completed TMDL studies for NPS impaired watersheds. Of these, 22 are having implementation plans developed at this time. There are 198 other TMDL studies underway on nonpoint source impaired watersheds. Table 4.1-5 lists these TMDLs by stage.

Whereas it is streams or water bodies that are listed as impaired, it is the watershed of those impaired stream segments and water bodies that are the focus of nonpoint source pollutant reduction activities. The hydrologic units listed in Table 4.1-5 are those in which some portion of the unit contains the listed impaired stream segment. Sometimes the entire area of the listed hydrologic unit is the watershed of the impaired stream segment, but often only a portion of that unit must be studied for a TMDL. Figure 4.1-18 shows the true TMDL study areas and thus gives a better indication of the geographic extent of where the work is being performed.

Agricultural Cost Share Program

The Virginia Agricultural Cost Share Program offers incentives to farmers and agricultural land owners to encourage the installation and use of a number of approved techniques (BMPs) for reducing agricultural related nonpoint source runoff. While the program aims to address nonpoint source pollutants statewide, specific hydrologic units are targeted based on the agricultural loads estimated from the NPS Assessment study (see Agricultural NPS Pollution Loads). Soil and Water Conservation Districts further target the practices to individual needs within their district within these priority areas.

Funding for the implementation of these practices has been borne by the state and the federal government since the program's inception in 1985. The number of installations per year has varied widely over the years, correlating with the variation of funding from the Water Quality Improvement Fund (WQIF) of the Commonwealth's Water Quality Improvement Act (WQIA). A consistent funding source for this program is needed to achieve maximum nutrient reductions.

Table 4.1-6 contains the estimated NPS pollutant reductions by basin for 2002 and 2003, as well as the state's costs to attain these reductions, from the Virginia Agricultural Cost Share Program alone. Other efforts, such as those of the USDA, increase these reductions. Additional information on agricultural best management practices can be found at www.dcr.virginia.gov/sw/costshar.htm.

Conservation Reserve Enhancement Program

The USDA's Conservation Reserve Program (CRP) provides incentives for the removal of agricultural land from production to protect environmentally sensitive land alongside rivers and streams. The Virginia Conservation Reserve Enhancement Program (CREP) augments CRP by providing for additional set-asides as well as by providing funding for land-owner implementation of other conservation practices as well as for the purchase of conservation easements.

Most areas of the state qualify for CREP assistance. Table 4.1-6 contains the estimated reduction of nonpoint source pollutants by basin for 2002 and 2003 from the Virginia CREP, as well as the state's costs to attain these reductions. The USDA's CRP increases these reductions. Additional information on the Conservation Reserve Enhancement Program can be found at www.dcr.virginia.gov/sw/crep.htm.

Table 4.1-6 BMP NPS Pollutant Reductions and Costs, Calendar Years 2002 & 2003

	Ag Cost Share Totals				CREP Totals			
BASIN	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)
POTOMAC	30836	167750	26591	614032	441	2398	589	31136
SHENANDOAH	19832	107883	21669	1744128	6850	37263	6615	435792
RAPPAHANNOCK	31546	171612	30531	1105485	1289	7015	1029	78005

YORK	11683	63554	10919	522703	3854	20966	3111	606632
JAMES	36691	199597	37144	1210920	4197	22833	4794	539935
BAY COASTAL	66900	363938	91365	270910	353	1918	283	51782
OCEAN COASTAL	27922	151895	37033	65440	83	452	104	11797
ALBEMARLE SOUND	1471	8003	1471	39781	18	96	18	400
CHOWAN	7451	40533	10859	149856	1171	6373	1645	145051
ROANOKE	49336	268387	53354	165600	1912	10400	1900	153198
YADKIN	1115	6066	1115	6495	3514	19116	3629	357139
NEW	16742	91075	16012	216046	7583	41252	7554	165957
CLINCH/POWELL	9230	50212	9589	125504	242	1316	300	56084
HOLSTON	106806	581025	113985	201772	1574	8562	1894	237880
BIG SANDY	143	775	143	1500	14	76	14	158

Tributary Strategies

Tributary Strategies are basin wide water quality plans designed to meet the pollution reduction goals of the Chesapeake Bay Program. They are part of the State's CBP commitment, and thus are described in that chapter of this 305(b) report. The goals of these plans directly specify both nonpoint source nutrient load reductions needed for water quality attainment and attainment measures that will require nonpoint source pollutant reductions. Consequently, significant amounts of nonpoint source pollutants must be reduced to achieve these plans, at considerable cost.

A nonpoint source pollution implementation plan has been developed and is being carried out, focusing on the primary sources of nonpoint source pollution. Increased funding is being provided through the WQIF. Addressing agricultural sources through cost-share and other programs is a priority. In addition, water quality initiatives that achieve measurable reductions will be funded in the urban and suburban arenas and competitive grants are being offered to local governments and nonprofits through Cooperative Nonpoint Source Local Programs for local water quality implementation projects that meet tributary strategy goals.